



UNIVERSITI PUTRA MALAYSIA

**DIETARY MANIPULATIONS USING OIL PALM
(ELAEIS GUINEENSIS) FRONDS TO INCREASE THE
UNSATURATED FATTY ACID CONTENT OF MUTTON
UNDER TROPICAL CONDITIONS**

GOH YONG MENG

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FRONDS TO INCREASE THE UNSATURATED FATTY ACID CONTENT
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By

GOH YONG MENG

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirement for the Degree of Doctor of Philosophy**

April 2002



*“Let food be thy medicine,
and medicine be thy food.”*

-- Hippocrates

*“To conceive of knowledge as a collection of information seems to rob the concept
of all its life...Knowledge resides in the user and not in the collection. It is how the
user reacts to a collection of information that matters.”*

-- Churchman, 1971

DEDICATION

*To the many beings that had made sacrifices for the advancement of Science
and the finalisation of their Karmas.*

Abstract of thesis presented to the Senate of Universiti Putra Malaysia
in fulfilment of the requirement for the degree of Doctor of Philosophy

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April 2002

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Faculty : Veterinary Medicine

Forty-three seven-month old Barbados Black Belly x Malin crossbred rams were used for the first trial which lasted 14 weeks, inclusive of two weeks of adjustment period. They were allotted into three treatment groups fed varying levels of oil palm (*Elaeis guineensis*) frond pellets and commercial sheep pellets. Treatment diets were 80 % commercial pellet + 20 % (% w/w) oil palm frond pellet (CON group, n=15), 50 % commercial pellet + 50 % oil palm frond pellet (% w/w) (HAF group, n=14) and 80 % oil palm frond pellet + 20 % (% w/w) commercial pellet (OPF group, n=14). The total lipids were extracted using the Folch method and methylated using 14 % methanolic Boron trifluoride with a known added amount of heneicosanoic acid (21:0) as an internal standard. The fatty acid methyl esters were separated by capillary column gas liquid chromatography and the fatty acids quantitated as absolute amounts or as percentage of total fatty acids.

The plasma and tissues of the CON animals had significantly ($P<0.05$) increased levels of unsaturated fatty acids (UFA) at the end of the trial compared to their initial values and both HAF and OPF groups. The increase in the UFA content was mainly due to the increased monounsaturated fatty acid (MUFA) content. The plasma and tissues of the HAF animals had the highest amount of saturated fatty acids (SFA) proportionately and in absolute amounts among the three treatment groups. The fatty acid unsaturation status of the plasma and tissues from the OPF animals was midway between those of the CON and HAF groups. All groups had low concentrations of EFA with unfavourable n-6:n-3 ratios. However, the CON animals had more ($P<0.05$) n-6 PUFA in their tissues, whereas the n-3 PUFA were more abundant ($P<0.05$) in the OPF animals. It was also noticed that the forequarter muscles were lower in n-3 PUFA compared to the hindquarter muscles.

Generally, the plasma lipids of the sheep were not markedly affected by their respective treatment diets. The weight gain was the highest in the CON group at 113 g/d and the lowest in the OPF group at 35 g/d. The carcass (Table 20) and meat characteristics (Table 21) obtained from 34 slaughtered animals were significantly different ($P<0.05$) between treatment groups with the best traits observed in the CON animals.

Nine surviving animals (three for each treatment group) from the first trial were used for the second trial. Oesophageal intubations were carried out at zero, two, four, six and eight hours post feeding on each animal to determine the changes

in the rumen conditions due to the treatment diets. The rumen pH was significantly different ($P<0.05$) between treatment groups. It was always in the decreasing order of OPF>HAF>CON at all time points. The rumen volatile fatty acids, ammonia nitrogen content, bacterial and protozoal counts were significantly different ($P<0.05$) between groups as well. The marked differences in the rumen conditions had resulted in the highest ($P<0.05$) amount of UFA present in the rumen of CON animals even after eight hours post-feeding. The UFA in the rumen contents of the CON animals (63.7 ± 6.1 mg/100mL) was two fold higher than those of HAF animals (31.9 ± 4.9 mg/100mL), and quadruple that of the OPF animals (12.1 ± 1.5 mg/100mL) at this point. Subsequently, this had led to the higher levels of UFA in the CON tissues and plasma as shown in the first trial.

In the third trial, seventy-five individually housed male Sprague-Dawley rats aged between six to seven months were used. Fifteen rats were selected randomly and sacrificed to establish the initial baseline values for the serum lipids at the onset of the trial. The remaining 60 rats were allotted randomly into five groups of 12 animals each. Three groups were fed with meat pellets derived from the mutton in the first trial. One group was fed with meat pellets prepared from commercially available mutton whole carcass for comparison purposes, and another group fed with standard rat chow as control. Blood and arterial tissue samples were obtained from the euthanised rats. Sampling was done on four animals from each group sacrificed serially at two, four and six weeks after the onset of the trial. Results showed that the CON mutton increased the rat serum HDL-Cholesterol significantly

($P < 0.05$) over those fed with the commercially available mutton. The serum HDL-Cholesterol levels in the CON mutton fed rats was 1.09 ± 0.31 mmol/L, while those fed commercially available mutton was 0.79 ± 0.10 mmol/L. The results on other serum lipids and arterial lesions were inconclusive.

In summary, the dietary manipulations demonstrated the feasibility of increasing the mutton UFA content to a level that would promote healthy changes in the consumers' blood lipid profiles, using sheep reared under tropical conditions fed diets formulated from oil palm frond pellets and commercial concentrates.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah

**MANIPULASI PEMAKANAN MENGGUNAKAN DEDAUN KELAPA
SAWIT (*ELAEIS GUINEENSIS*) UNTUK MENINGKATKAN
KANDUNGAN ASID LEMAK TAK TEPU DAGING BEBIRI
DALAM PERSEKITARAN TROPIKA**

Oleh

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Empat puluh tiga ekor bebiri jantan kacukan Barbados Blackbelly x Malin berumur tujuh bulan digunakan untuk eksperimen yang pertama selama 14 minggu. Bebiri tersebut dibahagikan secara rawak ke dalam tiga kumpulan. Bebiri ini diberi makan campuran bahan makanan yang terdiri daripada pellet dedaun kelapa sawit (*Elaeis guineensis*) dan konsentrat komersial. Kumpulan CON (n=15) diberi makan campuran 80 % (w/w) pelet dedaun kelapa sawit + 20 % (w/w) konsentrat komersial, kumpulan HAF (n=14) 50 % (w/w) pelet dedaun kelapa sawit + 50 % (w/w) konsentrat komersial, sementara kumpulan OPF mendapat 80 % (w/w) dedaun kelapa sawit + 20 % (w/w) konsentrat komersial. Kandungan asid lemak sampel diekstrak menggunakan kaedah Folch dan dirawat dengan larutan 14 % Boron trifluorida selepas penambahan sejumlah asid heneikosanoik (21:0) yang diketahui amaunnya sebagai piawaian dalaman. Metil ester asid lemak dipisahkan dengan mesin kromatografi gas yang dilengkapi kolum kapilari. Jumlah asid lemak

dalam sampel dilaporkan sebagai nilai mutlak, ataupun sebagai peratusan kepada jumlah asid lemak keseluruhan.

Plasma dan tisu bebiri CON menunjukkan peningkatan bererti ($P < 0.05$) kandungan asid lemak tak tepu (UFA) berbanding kedua-dua kumpulan HAF dan OPF di penghujung eksperimen. Peningkatan asid lemak tak tepu adalah kerana bertambahnya kandungan asid lemak monounsaturat (MUFA). Kandungan asid lemak tepu (SFA) dalam tisu dan plasma bebiri HAF adalah yang tertinggi di kalangan semua kumpulan bebiri. Sementara itu, tahap kandungan asid lemak tak tepu dalam bebiri OPF terletak di perantaraan kumpulan HAF dan CON. Kandungan asid lemak perlu (EFA) adalah rendah dalam semua kumpulan dengan nisbah n-6:n-3 yang kurang memberangsangkan. Bebiri CON mencatatkan kandungan asid lemak poliunsaturat n-6 yang terbanyak ($P < 0.05$), sementara kandungan asid lemak poliunsaturat n-3 adalah tertinggi dalam bebiri OPF. Keputusan juga menunjukkan kandungan asid lemak poliunsaturat n-3 otot bahagian suku depan adalah lebih rendah berbanding dengan otot bahagian suku belakang pada bebiri yang sama.

Secara amnya, manipulasi pemakanan tidak mendatangkan kesan yang mendadak terhadap tahap kolesterol dan parameter lain dalam serum bebiri. Penambahan berat badan adalah baik bagi bebiri di dalam kumpulan CON pada 113 g sehari. Bebiri OPF mencatatkan penambahan berat harian yang terendah sekali pada 35 g sehari. Ciri-ciri karkas (Jadual 20) dan daging (Jadual 21) berdasarkan 34

bebiri yang disembelih menunjukkan perbezaan bererti ($P < 0.05$) di antara kumpulan eksperimen. Bebiri CON menunjukkan profil karkas dan daging yang terbaik di antara tiga kumpulan tersebut.

Sembilan bebiri yang dikekalkan daripada eksperimen pertama telah digunakan untuk eksperimen kedua. Prosedur intubasi telah dilakukan pada setiap bebiri pada selang masa sifar, dua, empat, enam dan lapan jam selepas waktu makan terakhir untuk mengukur perubahan persekitaran rumen akibat manipulasi pemakanan. Bacaan pH rumen nyata berbeza ($P < 0.05$) di antara kumpulan dan sentiasa dalam urutan menurun $OPF > HAF > CON$ pada setiap selang masa. Takat asid lemak meruap, ammonia nitrogen, bilangan bacteria dan protozoa juga berbeza ($P < 0.05$). Perbezaan persekitaran rumen yang mendadak menyebabkan rumen bebiri CON mencatatkan kandungan asid lemak tak tepu yang tertinggi ($P < 0.05$) walaupun lapan jam selepas bebiri tersebut diberi makan. Kandungan asid lemak tak tepu dalam haiwan CON (63.7 ± 6.1 mg/100mL) adalah dua kali ganda lebih banyak berbanding kumpulan HAF (31.9 ± 4.9 mg/100mL), dan empat kali ganda lebih banyak daripada haiwan OPF (12.1 ± 1.5 mg/100 mL). Kesannya, haiwan dari kumpulan CON mempunyai tahap asid lemak tak tepu yang tertinggi seperti yang telah ditunjukkan oleh keputusan dari eksperimen pertama.

Eksperimen ketiga menggunakan tikus Sprague-Dawley berumur di antara enam sehingga tujuh bulan. Lima belas ekor tikus dipilih secara rawak pada permulaan eksperimen dan dikorbankan untuk mendapat bacaan dasar parameter

darah yang diukur. Enam puluh tikus yang selebihnya dibahagikan secara rawak kepada lima kumpulan yang terdiri daripada 12 haiwan setiap satu. Tiga kumpulan diberi makan pelet daging bebiri daripada eksperimen satu, satu kumpulan diberi makan pelet daging daripada daging bebiri komersial, dan kumpulan tikus terakhir diberi makan pelet tikus dan bertindak sebagai kontrol. Sampel darah dan tisu arteri diperolehi daripada tikus-tikus ini apabila empat ekor tikus setiap kumpulan dikorbankan secara bersiri pada dua, empat dan enam minggu selepas eksperimen dimulakan. Keputusan menunjukkan bahawa tikus yang memakan daging CON (1.09 ± 0.31 mmol/L) mencatatkan peningkatan HDL-Cholesterol tertinggi yang bererti ($P < 0.05$) berbanding daging bebiri komersial (0.79 ± 0.10 mmol/L). Walaubagaimanapun, keputusan lipid serum yang lain dan lesi arteri tidak nyata.

Kesimpulannya, kaedah manipulasi pemakanan yang dipraktikkan ini boleh diterima-pakai untuk meningkatkan kandungan asid lemak tak tepu daging bebiri ke tahap yang akan memanfaatkan kesihatan pengguna. Kaedah-kaedah yang dibangunkan ini adalah berdasarkan campuran bahan makanan berteraskan pelet dedaun kelapa sawit dan konsentrat komersial dan sesuai untuk keadaan dan baka bebiri tropika.

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I certify that an Examination Committee met on 08 April 2002 to conduct the final examination of Goh Yong Meng on his Doctor of Philosophy thesis entitled “Dietary Manipulations Using Oil Palm (*Elaeis guineensis*) Fronds to Increase the Unsaturated Fatty Acid Content of Mutton Under Tropical Conditions” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or currently submitted for any other degree at UPM or other institutions.



GOH YONG MENG

Date : 02 MAY 2002

TABLE OF CONTENTS

	Page
DEDICATION.....	ii
ABSTRACT.....	iii
ABSTRAK.....	vii
ACKNOWLEDGEMENTS	xi
APPROVAL.....	xiii
DECLARATION.....	xv
LIST OF TABLES.....	xxii
LIST OF FIGURES.....	xxv
LIST OF PLATES.....	xxviii
LIST OF ABBREVIATIONS.....	xxix

CHAPTER

I	GENERAL INTRODUCTION.....	1
	Lipid and Trends in Human Health	1
	General Objectives and Organisation of the Study	3
II	LITERATURE REVIEW.....	6
	Lipid and Fatty Acids	6
	Fatty Acids in Terrestrial Mammals	8
	Significance of Fatty Acids	10
	Fatty Acid Analysis	16
	Fatty Acid Metabolism in the Rumen	20
	The Rumen Ecosystem	20
	Rumen Biohydrogenation	25
	Effects of Dietary Fatty Acids on Ruminant Digestion	30
	Effects of Dietary Fatty Acids on Ruminal Flora	33
	Effects of Dietary Fatty Acids on Selected Physiological Processes	36
	The Digestion and Absorption of Fatty Acids in Ruminants and Monogastrics	37
	Lipoprotein Metabolism and Transport of Fatty Acids	42
	Fatty Acid Metabolism in Monogastrics and Ruminants	49
	SFA Synthesis	50
	UFA Synthesis	53
	EFA Metabolism	54
	Fatty Acid Catabolism	55
	Factors That Determine Fatty Acid Profiles in Ruminants	59
	Anatomical Locations	59
	Tissue and Organ Types	60
	Age and Live Weight Factors	61

Breed and Genetic Factors	62
Sex Factors	62
Hormonal Factors	63
Fat Sources and Types	64
Protein Levels	67
Energy Levels	68
Forage and Concentrate Inclusion Levels	69
Rumen Protozoa Faunation Status	71
Miscellaneous Factors	73
Alteration of the Mutton Fatty Acid Profile	74
Changes on Meat Quality Following the Changes in Tissue Fatty Acid Profile	76
Meat Consumption Patterns in Malaysia	77
The Small Ruminant Industry in Malaysia	79
The Oil Palm Frond as Ruminant Feed	82
Fatty Acids in Human Health	83
Roles of SFA	85
Roles of UFA	86
Roles of Trans Fatty Acids	88
Possible Mechanisms Regulating Blood Lipid Changes	89
Importance of U:S, P:S and n-6:n-3 Ratios	90
Lipid Intake Recommendations	92
Atherosclerosis	92
Pathogenesis of the Atherosclerotic Lesions	94
Atherosclerotic Lesions	96
Conclusions	100
III GENERAL APPROACH OF THE STUDY AND EXPERIMENTAL PROCEDURES.....	102
Chronological Scheduling of Experiments	102
Experimental Locations and Animal Housing	106
Experimental Animals	107
Experimental Diets	108
Fatty Acid Profile Determination	110
Chemicals and Glassware	110
Total Lipid Extraction	110
Preparation of Fatty Acid Methyl Esters (FAME)	112
Gas Liquid Chromatography	114
Proximate Analysis	115
Dry Matter	115
Nitrogen Content Determination	115
Ash	117
Ether Extract	118
Crude Fibre	119
Gross Energy Content	120

Plasma and Serum Biochemical Determinations	123
Total Cholesterol	123
High Density Lipoprotein-Cholesterol	125
Low Density Lipoprotein-Cholesterol	125
Triacylglycerol	126
Serum Calcium	128
Serum Magnesium	129
Data Analysis	130
 IV PHASE I : EFFECTS OF THE DIETARY MANIPULATION ON THE SHEEP PLASMA AND TISSUE FATTY ACID PROFILES.....	 131
Introduction	131
Objectives	134
Materials and Methods	134
Animal Management	134
Blood and Feed Samplings	135
Tissue Samplings	136
Data Analysis	137
Results	138
Composition of the Treatment Diets	138
Fatty Acid Profile of the Treatment Diets	140
Fatty Acid Profile of the Sheep Plasma	144
Total SFA Content of the Sheep Tissues	158
Total UFA Content of the Sheep Tissues	172
Total MUFA Content of the Sheep Tissues	176
Total n-3 PUFA Content of the Sheep Tissues	180
Total n-6 PUFA Content of the Sheep Tissues	184
The U:S Ratios of the Sheep Tissues	188
The n-6:n-3 Ratios of the Sheep Tissues	188
The P:S Ratios of the Sheep Tissues	189
Comparisons of the Tissue Fatty Acid Profiles within Treatment Groups	189
Discussions	198
Plasma Fatty Acid Profiles	198
Tissue Fatty Acid Profiles	199
Tissue U:S, n-6:n-3 and P:S Ratios	203
Relationship between Tissue and Plasma Fatty Acid Profiles	204
Fatty Acid Profiles of the Working Muscles Versus Non-Working Muscles	205
Relative Resistance of Tissue Fatty Acid Profiles to Dietary Manipulation	206
Changes Affecting the Dietary Fatty Acids in the Rumen	209
Probable Effects of Dietary Energy and Protein	

	Levels on Fatty Acid Profiles	211
	Conclusions	213
V	PHASE I : EFFECTS OF THE DIETARY MANIPULATION ON THE PLASMA LIPID CHANGES, RUMEN CONDITIONS, GROWTH AND CARCASS CHARACTERISTICS OF SHEEP.....	214
	Introduction	214
	Objectives	216
	Materials and Methods	216
	Blood Lipid Determinations	217
	Growth and Carcass Analysis	218
	Determination of Rumen pH	221
	Data Analysis	222
	Results	223
	Plasma Total Cholesterol	223
	Plasma Triacylglycerols	223
	Plasma HDL-Cholesterol	226
	Body Weight Gain and Growth Characteristics	226
	Carcass Traits and Characteristics	230
	Rumen pH	234
	Discussions	236
	Effects on Plasma Triacylglycerols	236
	Effects on Plasma HDL-Cholesterol	236
	Effects on Plasma Total Cholesterol	237
	Live Weight Gains	238
	Carcass Characteristics	240
	Ruminal pH	241
	Conclusions	244
VI	PHASE II : EFFECTS OF DIETARY MANIPULATION ON THE CONDITIONS IN THE RUMEN OF SHEEP..	245
	Introduction	245
	Objectives	249
	Materials and Methods	249
	Rumen Fluid Measurements and Fixation	
	Procedures	250
	Ammonia Nitrogen	251
	Protozoal and Bacterial Counts	251
	Volatile Fatty Acid Assay	251
	Rumen Fluid Fatty Acid Assay	252
	Data Analysis	252
	Results	253
	pH	253
	Ammonia Nitrogen Levels	255
	Holotrichs Density	255

Entodiniomorphs Density	257
Total Protozoal Density	258
Total Bacteria Density	259
Bacteria to Protozoa Ratios	261
Total Volatile Fatty Acids	262
Molar Proportions of the Rumen Volatile Fatty Acids	262
Total Fatty Acids in Rumen Fluid	265
Oleic, Linoleic, Linolenic, Stearic and Palmitic Acids	267
Total SFA, UFA and MUFA	271
The U:S and P:S Ratios	278
Discussions	280
Rumen pH	280
Rumen Ammonia Nitrogen	283
Rumen Protozoa	285
Rumen Bacteria	288
Rumen Volatile Fatty Acids	290
Rumen Fatty Acids	292
Conclusions	295
VII PHASE III : EFFECTS OF FEEDING MODIFIED MUTTON TO RATS.....	296
Introduction	296
Objectives	299
Materials and Methods	300
Rats	300
Preparation of the Treatment Diets	301
Serum Lipid and Mineral Ion Determinations	303
Rat Weight	303
Staining of the Rat Aorta	303
Data Analysis	304
Results	305
Nutrient Composition of the Rat Feeds	305
Fatty Acid Profile of the Rat Feeds	307
Effect of the Pelleting Process on Meat-based Rat Pellets	310
Fatty Acid Losses in the Drip Loss Portion of Meat Samples	315
Rat Weights	317
Total Serum Cholesterol in Rats	317
Serum Triacylglycerols in Rats	319
Serum HDL-Cholesterol in Rats	319
Serum LDL-Cholesterol in Rats	322
Serum Magnesium levels in Rats	324
Serum Calcium in Rats	324

Vascular Changes	326
Discussions	326
Fatty Acid Profile of the Rat Pellets	329
Serum Total Cholesterol	330
Serum Triacylglycerol	331
Serum LDL and HDL Cholesterols	332
Serum Magnesium and Calcium Levels	333
Arterial Lesions	334
Limitations of the Study	335
Conclusions	337
VIII GENERAL DISCUSSION.....	338
IX GENERAL CONCLUSIONS.....	354
BIBLIOGRAPHY.....	358
APPENDIX A.....	395
APPENDIX B.....	404
VITA.....	412

LIST OF TABLES

Table		Page
1	Nutrient composition of the sheep treatment diets	139
2	Fatty acid profile comparison between the oil palm frond pellets and commercial concentrate pellets	141
3	Fatty acid composition of the sheep treatment diets	143
4	The fatty acid profiles of the sheep plasma before the feeding trial	145
4a	The fatty acid profiles of the sheep plasma at Week 1	146
4b	The fatty acid profiles of the sheep plasma at Week 4	147
4c	The fatty acid profiles of the sheep plasma at Week 8	148
4d	The fatty acid profiles of the sheep plasma at Week 12	150
5	The fatty acid profiles of the sheep <i>longissimus dorsi</i>	161
6	The fatty acid profiles of the sheep <i>psoas major</i>	162
7	The fatty acid profiles of the sheep <i>gluteus medius</i>	163
8	The fatty acid profiles of the sheep <i>semimembranosus</i>	164
9	The fatty acid profiles of the sheep <i>triceps brachii</i>	165
10	The fatty acid profiles of the sheep liver	166
11	The fatty acid profiles of the sheep brain	167
12	The fatty acid profiles of the sheep kidney	168
13	The fatty acid profiles of the sheep heart	169
14	The fatty acid profiles of the sheep lungs	170
15	Effects of treatment diets on fatty acid types in sheep tissues	207
16	The cholesterol levels in sheep plasma	224

Table	Page
17 The triacylglycerol (TAG) levels in sheep plasma	225
18 The HDL-Cholesterol levels in sheep plasma	227
19 Sheep weight and daily gains	228
20 The comparisons between sheep carcass attributes	231
21 The results of the sheep left half carcass analysis	233
22 Rumen pH in sheep slaughtered at fixed intervals post-feeding	235
23 pH values in post-feeding rumen fluid	254
24 Ammonia nitrogen levels in post-feeding rumen fluid	254
25 Protozoal densities in post-feeding rumen fluid	256
26 Bacterial densities in post-feeding rumen fluid	260
27 Bacteria to protozoa ratios in post-feeding rumen fluid	260
28 Total volatile fatty acid levels in post-feeding rumen fluid	263
29 Total volatile fatty acid levels and molar proportions of individual volatile fatty acids in post-feeding rumen fluid	264
30 Total fatty acid levels in post-feeding rumen fluid	266
31 Stearic, oleic, linoleic acid levels in post-feeding rumen fluid	268
32 Palmitic, linolenic and trans 18:1 fatty acid levels in post-feeding rumen fluid	269
33 Total SFA, UFA, MUFA levels in post-feeding rumen fluid	276
34 The U:S and P:S ratios in post-feeding rumen fluid	279
35 Nutrient composition of the rat treatment diets	306
36 Fatty acid composition of the rat treatment diets	308

Table	Page
37 Comparison of the fatty acid composition of the of the OPF meat in ground meat and oven dried pellets	311
38 Comparison of the fatty acid composition of the of the HAF meat in ground meat and oven dried pellets	312
39 Comparison of the fatty acid composition of the of the CON meat in ground meat and oven dried pellets	313
40 Comparison of the fatty acid composition of the of the Commercial meat in ground meat and oven dried pellets	314
41 Detected fatty acids from the drip loss of thawed meat	316
42 The total cholesterol levels in rat serum	318
43 The triacylglycerol levels in rat serum	320
44 The HDL-Cholesterol levels in rat serum	321
45 The LDL-Cholesterol levels in rat serum	323
46 The serum magnesium levels in rats	325
47 The serum calcium levels in rats	325
48 Sudanophilic changes on the rat aortic intima	327
49 The fatty acid profiles of the sheep plasma at Week 2	396
50 The fatty acid profiles of the sheep plasma at Week 3	397
51 The fatty acid profiles of the sheep plasma at Week 5	398
52 The fatty acid profiles of the sheep plasma at Week 6	399
53 The fatty acid profiles of the sheep plasma at Week 7	400
54 The fatty acid profiles of the sheep plasma at Week 9	401
55 The fatty acid profiles of the sheep plasma at Week 10	402
56 The fatty acid profiles of the sheep plasma at Week 11	403